NOTES ON X-RAYS IN MEDICINE.

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DURING the past two or three months I have been much interested in studying the x-rays, and with the assistance of Mr. C. L. Norton and Mr. R. R. Lawrence, of the Massachusetts Institute of Technology, who have been investigating the x-ray problem in the Rogers Laboratory of Physics, have tested the application of x-rays to medicine in various ways. Their application to surgery was soon evident; pictures of all the bones can be taken that show their structure and details with marvellous clearness; not only is the bony structure of the extremities but also that of the larger bones and of the joints, for example, the comparatively superficial joints, such as the shoulder, the elbow, and especially the ankle (Fig. 1) beautifully shown, and Fig. 2 demonstrates that the deep hip-joint and the neck of the femur are to be within our reach for the diagnosis of dislocations and fractures; the trochanters of the femur and its spherical head, and the portion of the head outside and inside the acetabulum can be photographed, as well as the whole bony structure of the pelvis, even the details of the sacrum showing. The medullary canal of the long bones, as, for instance, the shaft of the femur, is distinctly shown, and it is not improbable that we may be able to distinguish changes in the bone-marrow. Fractures and dislocations, and also diseased conditions of the bones involving change of structure or density, changes in the joints themselves, aside from the bones, may be studied with profit by the x-rays. In some of the negatives the outlines of muscles and tendons are indicated. The development of the skeleton at different ages may also be well studied.

[1] I have included in this paper some observations made soon after the meeting.

Pieces of metal impervious to the rays, such as bullets, may be located with precision. To do this two views are necessary: one to show the position from right to left, and the other the distance from the front or back.

The following cases will illustrate this use of the rays:

A patient from the Boston City Hospital, who was thought to have a bullet in his right forearm, was brought to me for examination. The bullet was readily detected by the fluoroscope about the middle of the radius, some distance from its point of entrance, which was near the wrist. I marked the position of the bullet on the skin from two points of view in order to indicate to the surgeon the size and place of the bullet. It was found in the radius, and the size corresponded to what we saw in the fluoroscope.

A patient of Dr. Charles McCarthy, of Franklin, Mass., was referred to me by Dr. George H. Monks, of Boston. She had been shot in the back ten weeks previously, the 38-calibre bullet entering through the lower portion of the scapula; but it had not been found. A photograph taken of the left side of the thorax, including the spinal column, the shoulder-joint, and the humerus, did not reveal the bullet, but showed where it had pierced the scapula and broken a rib, and at one of these points a small piece of lead seemed to have been left as it passed. I could state with confidence that the bullet itself was not in that part of the body, as with the fluoroscope we could see distinctly a piece of lead-wire only one-eighth of an inch in diameter when held on the opposite side of the patient from the observer. On the following day photographs (Figs. 4 and 5) which included the neck and upper portions of both sides of the thorax, was taken, and the bullet exactly located at the base of the neck.

My brother, Dr. Charles H. Williams, lately brought a patient to me for examination who was thought to have a piece of copper in one of his eyes. I was not very sanguine about the result of the examination, and we therefore first tested the matter in a rough way by placing a piece of bent copper-wire of about the diameter of the lead of a lead-pencil, on one of Mr. Norton's temples. The Crookes tube was placed near his temple and the photographic plate on the other side of the head, in order to make the test as severe as possible. Finding that the wire could be easily seen in the negative, even though placed far from the plate, we then proceeded to photograph the patient's eye,

which we placed near the plate to give it every possible advantage. The position of the eyeball could be distinctly seen in the picture, and in about the centre of the eye was a spot corresponding, as we thought, to the piece of copper said to have penetrated it. Dr. Williams then operated and found and removed a flat piece of copper $\frac{1}{8}$ by $\frac{1}{4}$ of an inch, which was similar in shape to what we had seen in the negative.

But I wish especially to direct your attention to some of the medical rather than the surgical uses of these magical rays, and especially to their use with the fluoroscope; in the fluoroscope with a screen of tungstate of calcium the parts of the body which are most easily passed by the x-rays appear lightest on the screen, those which are densest being darker. The lungs are easily penetrated, the ribs, clavicles, and vertebræ being in marked contrast to other portions of the thorax (Fig. 3). The density of the lungs is much less than that of the other organs and the fact that their density is increased in many diseased conditions will make the x-rays serviceable in diagnosis. Against the lower part of the right lung the outline of the upper portion of the liver is distinctly seen, and the rise and fall with the respirations easily followed. Between extreme inspiration and expiration the liver moves vertically about three inches. Below the left lung is seen the spleen, and by raising and lowering the Crookes tube while looking through the fluoroscope one may so adjust the tube as to follow the outline of the spleen completely, and also to see the lower border of the liver on the right side. By looking through the body from side to side with the fluoroscope, the observer being on the patient's right, the whole outline of the great mass of the liver may, under favorable conditions, be seen hanging in the vault of the diaphragm. On examining one patient, I found that he could move his liver by inspiration and expiration less than an inch, and as there was a history of localized peritonitis a year previously, it is possible there were adhesions limiting the movement of the liver.

The pulsations of the heart may be followed with the fluoroscope, not only the ventricular, but also the auricular contractions and dilatations.

In the following cases the usual physical examination and that made with the fluoroscope corresponded very well:

CASE I.—The first medical case I examined was that of a man with an enlarged heart (seven inches in transverse diameter). I found that the outline of the heart, as seen from the front of the body through the fluoroscope, corresponded in a general way to the outline drawn on the skin with percussion as a guide. It was interesting to note that the heart could be made out through the man's waistcoat and two shirts.

CASE II.—In one of my patients, who was recovering from pneumonia, the signs by auscultation and percussion, which were only in the lower part of the right chest, were moderate dulness, slight bronchial respiration, and a few râles two fingers' breadth above the right base in the back; nothing in the chest in front.

By the fluoroscope: Clear area at right apex; darker area in lower right chest, apparently extending about two inches above level of liver.

CASE III. was a patient of one of my colleagues, who was suffering from tuberculosis of the right lung. His hospital record was as follows:

January 31, 1896. C. B., aged twenty years. Left lung negative; dulness at right apex, and just below this an area of tympany, over which is heard amphoric breathing. At apex expiration prolonged, and fine moist and crackling râles. Dulness in back nearly to scapula, with numerous fine, moist, and crackling râles.

April 14*th.* Dulness in upper two-thirds of right back; tubular respiration on top and rather obscure breathing below, with rather dry râles over area of dulness. Percussion at second space dull rather than tympanitic. Tubular respiration rather more circumscribed, and most marked toward anterior axillary line. Fine, dry râles, increased by cough, extending about two-thirds down.

After looking at this patient from behind for a moment only, the difference in the amount of rays which passed through the two sides of the chest was very striking, as seen through the fluoroscope, the diseased lung, as I had predicted, being darker throughout than the normal lung. The ribs on the left side were much more distinct than those on the right.

CASE IV.—A. B. In this patient symptoms of tuberculosis began six weeks before she came under my care. I found the physical signs as follows:

On the right side, in front, increased voice-sounds and increased vocal fremitus from apex to third rib, with high-pitched medium moist râles above and just below the clavicle, not lower than the second rib. *Behind:* Dulness, moderate bronchial breathing, and moderate number of râles from apex to one inch above angle of scapula. By fluoroscope: Examination of lungs showed a darker area in right upper half of chest, the rays passing through the left apex very well.

As we have seen by the cases just cited, the fluoroscope is already of service in assisting the physician to determine the position and extent of some of the diseases of the respiratory system and the position and size of the heart, likewise the position, size, and mobility of

the liver and spleen. By its aid we may in some cases of tuberculosis have an earlier warning of the disease than by the other physical signs hitherto at our disposal. To make these observations it is necessary to have good apparatus and to be able to vary readily the position of the Crookes tube while looking through the fluoroscope. We used a Wimshurst machine with twelve plates, each twenty-six inches in diameter, designed by Messrs. Norton and Lawrence, and it has given excellent results, much better than those obtained with the alternating current; the pictures with the Wimshurst machine being sharply defined and clear and the tubes not being destroyed. A photograph of the bones of the hand can be taken by this machine after an exposure of five seconds or less, although a longer exposure gives more detail.

In using the fluoroscope it is important to bear in mind the relative position of this instrument, the Crookes tube, and the organ which is under observation. For example, in examining the heart a good position for the tube is about on a level with the heart in front of the patient and a little to the right of his median line; the patient should not face the tube squarely, but should be placed with his right side turned a little toward it; the observer, standing behind the patient and holding the fluoroscope to the left back of the latter, thus sees the shadow of the apex of the heart projected on the screen of the fluoroscope far to the left, even touching the left posterior axillary line, thus bringing a large part of the heart into view.

It is sometimes of service to be able to vary the length of the spark while observing with the fluoroscope, as the character of the picture changes with the character of the light. For instance, with a long spark the medullary canal of the long bones is distinctly visible, while with a short one this disappears and the bones become darker.

Some months ago Mr. S. C. Keith, Jr., of the Biological Department of the Massachusetts Institute of Technology, brought cultures of bacteria to Mr. Norton, for exposure to the x-rays. Tubes of melted nutrient gelatin were inoculated by Mr. Keith with the bacteria named below, and this gelatin was then poured out into a sterilized Petri dish, over which it formed a thin layer, and allowed to cool. One-half of the dish was covered with a thick plate of brass, through which the x-rays do not pass, and the dish was then put into

a tight pasteboard box which was placed about four inches from the Crookes tube. The bacilli used were exposed as follows:

Bacillus anthracis	5 minutes.
Bacillus typhi abdom.	5 "
Bacillus " "	20 "

In the above-mentioned experiments the Petri dishes had glass covers; in the following, very thin aluminum covers were used:

Bacillus coli communis	1 hour.
Bacillus prodigiosus	1 "
Bacillus "	2 "
Bacillus "	4 "

After this exposure the Petri dishes still enclosed in the box were incubated from twenty-four to forty-eight hours at 37° Cent. Examination thereafter showed that the colonies of bacteria developed equally well on the exposed and unexposed side of the dishes.

In order to make a comparison between the effect of the x-rays and the sun's rays on bacteria, the bacillus coli communis and the bacillus prodigiosus were exposed to not very bright sunlight (the day was hazy) for fifteen minutes, the experiments being conducted in the same manner as those above described. The incubator showed that the bacteria exposed to the sun's rays were killed.

Explanation of Plates.

Fig. 1.—Foot with shoe on.

Fig. 2.—The hip-joint of a woman. The sacro-iliac synchondrosis is also shown as well as a portion of the sacrum.

Fig. 3.—The thorax of a woman.

Fig. 4.—This picture was taken with the Crookes tube on the right side of the neck and the photographic plate on the left side. The bullet was just behind the sterno-cleido-mastoid muscle. It is seen in the illustration in front of the vertebræ; the lighter area behind it is the trachea, and above this are the larynx and epiglottis, and crossing the epiglottis is the hyoid bone. The dark area at the top of the picture is the angle of the lower jaw.

Fig. 5.—Picture of the same taken from behind.

FIG. 1.

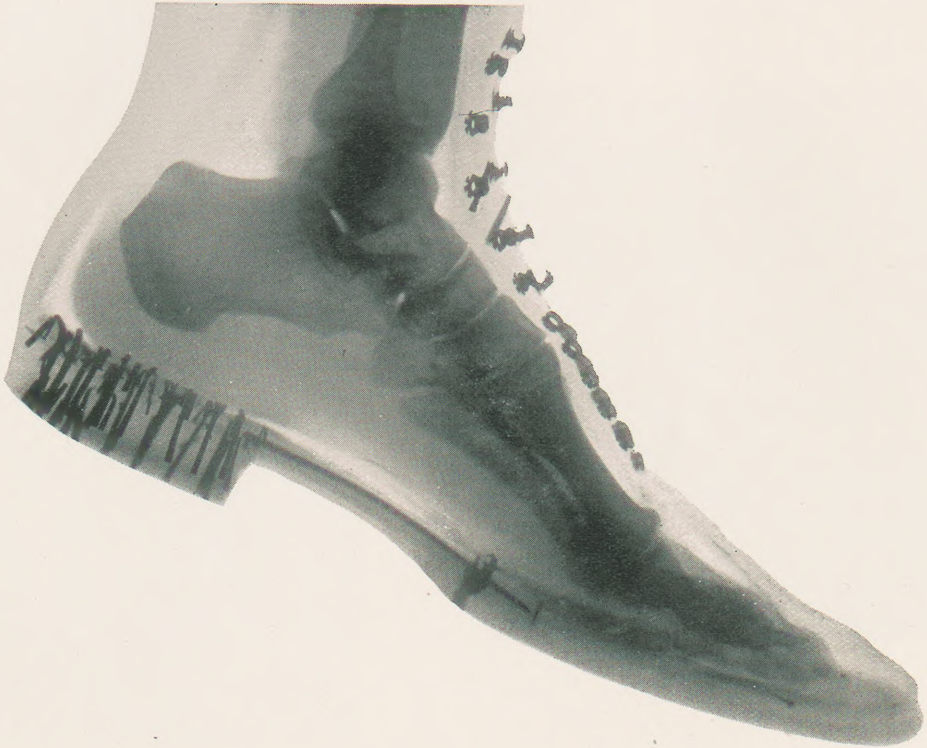

Fig. 2.

Fig. 3.

FIG. 4.

FIG. 5.